Surface nanophotonics with Bloch waves on dielectric multilayers

E. Descrovi[1], M. Ballarini[1], F. Frascella[1], A. Angelini[1,2], A. Lovera[3], E. Enrico[2],T. Sfez[4], N. De Leo[2], P. Mandracci[1], H.P. Herzig[4], O.J.F. Martin[3], F. Michelotti[5], F. Giorgis[1]

[1]Politecnico di Torino, Department of Applied Science and Technology, Torino IT-10129, Italy
[2]National Institute of Metrological Research, Torino IT-10135, Italy
[3]Ecole Polytechnique Fédérale de Lausanne (EPFL), Nanophotonics and Metrology Laboratory, Lausanne CH-1015, Switzerland
[4]Ecole Polytechnique Fédérale de Lausanne (EPFL), Optics & Photonics Technology Laboratory Neuchâtel, CH-2000, Switzerland
[5]SAPIENZA Università di Roma, Department of Basic and Applied Sciences for Engineering, Roma IT-00161, Italy
email: emiliano.descrovi@polito.it

Summary

Planar mutilayers sustaining either TE or TM polarized Bloch Surface Waves (BSWs) offer new opportunities for management of light at the nanoscale. We will discuss how BSWs can be exploited in guiding and confining light on nanometric relieves, enhancing fluorescence emission and providing additional features for plasmonic nano-antennas.

Introduction

Bloch Surface Waves (BSW) are either TE- or TM-polarized electromagnetic waves that can be coupled at the surface of proper truncated periodical structures such as one-dimensional photonic crystals (1DPC) [1-3]. To some extent, BSWs can be considered as the dielectric equivalent of Surface Plasmon Polaritons (SPPs) for metals. Compared to SPPs, BSWs present some advantages, especially for sensing applications. Firstly, BSW-based detection does not suffer from signal losses, since the enhancing medium is made of dielectrics. Secondly, when using fluorescence, the distance between the emitters and the 1DPC surface is less critical due to the absence of quenching (e.g. charge transfer) effects induced by the presence of metals. Finally, depending on the materials used and the multilayer design, a wide range of spectral tunability can be obtained for BSW coupling.

In this work we provide an overview of our recent results on light manipulation at the nanoscale through coupling of BSWs. In particular, we will consider three main aspects of interest: the confinement and guidance of BSWs on nanometric relieves upon external illumination; the local BSW coupling of fluorescence emitted by organic dyes grafted on structured 1DPC; the hybridazion of BSW modes with localized plasmonic modes sustained by metallic resonant nano-structures such as nano-antennas.

Discussion

A direct means for observing the lateral confinement of BSWs on nanometric relieves is represented by SNOM. After performing an accurate SNOM analysis of guided BSW (GBSW) modes coupled on ultra-thin polymeric ridges in the near infrared region [4-5],

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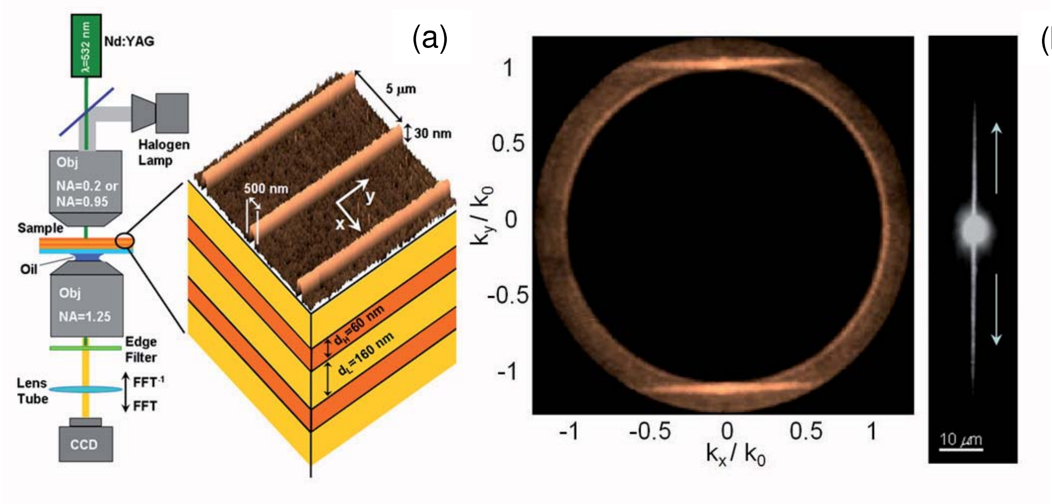
we demonstrated the possibility of laterally localize BSW taking advantage of pure refractive effects. An analogous confinement/guidance effect has been observed in the visible range, by considering the coupling of fluorescence emitted by organic dyes grafted on nanometric waveguides (20nm thick, 500nm wide) as depicted in the figure. In this case, useful information can be extracted by means of Leakage Radiation Microscopy (LRM) performed both on the direct and on the Fourier planes [6].



(a) LRM setup for detecting fluorescent GBSW on nanometric ridges (AFM map on multilayer sketch);
(b) Fourier and direct plane images of fluorescent GBSW on single guide.

When dealing with metallic nano-objects exhibiting a plasmonic resonant behaviour, BSWs can interact (strongly or weakly) with localized plasmons and hybridize (vacuum Rabi splitting for strong interaction) or enhancing the near-field intensity produced e.g. in the gap on dipole antennas.

Conclusions

Dielectric multilayers sustaining BSWs in different spectral regions are presented. This rather simple architecture can provide a useful tool for engineering or improving nano-photonics effects such as near-field localization and fluorescence enhancement.

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